

WE CLAIM:

1. A method for manufacturing a semiconductor device, the method comprising, in sequence, the steps of:

providing a semiconductor substrate, the substrate comprising a first film being one of a diffusion barrier film and a metal film, the first film being exposed at least at part of the surface area of said substrate;

exposing the substrate to an oxygen-containing reactant to create a surface termination of about one monolayer of oxygen-containing groups or oxygen atoms on the exposed parts of the first film; and

depositing a second film onto the substrate, being the other of a diffusion barrier film and a metal film.

2. The method of claim 1, wherein the oxygen-containing reactant is a hydroxyl-containing reactant and wherein the exposure with the hydroxyl-containing reactant is performed under ALD conditions to create a surface termination of about one monolayer of hydroxyl groups on the exposed parts of the first film.

3. The method of claim 2 wherein the step of exposing the substrate to a hydroxyl-containing reactant under ALD conditions to create a hydroxyl-terminated surface on the exposed parts of the first film comprises subjecting the substrate to a repeated and alternating sequence of a metal-containing reactant exposure step and a hydroxyl-containing reactant exposure step under ALD conditions wherein the sequence is repeated one to fifty times to form about one monolayer of hydroxyl-terminated metal on the exposed parts of the first film.

4. A method for manufacturing a semiconductor device, the method comprising, in sequence, the steps of:

providing a semiconductor substrate;

depositing a diffusion barrier onto the substrate by ALD;

exposing the substrate to an oxygen-containing reactant to create a surface termination of about one monolayer of oxygen-containing groups or oxygen atoms on the diffusion barrier; and

depositing a metal film on the substrate.

5. The method of claim 4 wherein the oxygen-containing reactant is a hydroxyl-containing reactant and wherein the exposure with the hydroxyl-containing reactant is performed under ALD conditions to create a surface termination of about one monolayer of hydroxyl groups on the diffusion barrier.

6. The method of claim 5 wherein exposing the substrate to a hydroxyl-containing reactant to form a hydroxyl-terminated surface comprises subjecting the substrate to a repeated and alternating sequence of a metal-containing reactant exposure step and a hydroxyl-containing reactant exposure step under ALD conditions wherein the sequence is repeated one to fifty times to form about one monolayer of hydroxyl-terminated metal on exposed parts of the first film.

7. The method of claim 4 wherein said metal film is a copper film.

8. The method of claim 4 wherein said diffusion barrier is TiN.

9. The method of claim 4 wherein said hydroxyl-containing reactant is at least one of water vapor, an alcohol and a carboxylic acid.

10. The method of claim 9 wherein said alcohol is one of methanol, ethanol, and propanol, and wherein said carboxylic acid is one of formic acid and acetic acid.

11. An oxygen bridge structure comprising:  
• a diffusion barrier film;  
a metal film, having an interface with the diffusion barrier film; and

about a monolayer of oxygen atoms at the interface between the diffusion barrier film and the metal film, the oxygen atoms forming bridges between diffusion barrier film atoms and metal film atoms.

12. The oxygen bridge structure of claim 11 wherein the diffusion barrier film is a transition metal nitride, carbide, phosphide or boride or a transition metal or mixtures of said materials.

13. The oxygen bridge structure of claim 11 wherein the metal film comprises Cu, Al, Ni, Co or Ru.

14. A semiconductor device comprising a dual damascene structure, wherein the dual damascene structure comprises an oxygen bridge structure according to claim 10.

15. A conductive pathway in an integrated circuit, comprising:

a diffusion barrier film comprising a material selected from the group consisting of metal nitrides, metal carbides, metal phosphides and metal borides; and

a metal conductor adjacent the diffusion barrier film; and

a metal oxide bridge material sandwiched between the diffusion barrier film and the metal conductor, the bridge material having a thickness of no more than about five monolayers.

16. The conductive pathway of claim 15, wherein the diffusion barrier film comprises a material selected from the group consisting of transition metal nitrides, transition metal carbides, transition metal phosphides and transition metal borides.

17. The conductive pathway of claim 16, wherein the metal oxide bridge material has a thickness uniformity across the diffusion barrier characteristic of atomic layer deposition.

18. The conductive pathway of claim 15, wherein the bridge material has a thickness of no more than about three monolayers.